Occupational Safety Competency 1.1

Competency 1.1 **Occupational safety personnel shall demonstrate a working level knowledge of electricity and electrical hazards to enable them to develop, implement, and evaluate an electrical safety program.**

1. Supporting Knowledge and Skills

a. Discuss general terminology associated with electricity and electrical hazards.

b. Discuss specific terminology applicable to:
- Measurement of electricity
- Power systems
- Electrical distribution systems
- Protective devices

c. Discuss the major safety concerns and appropriate control measures for working on or near electrical equipment.

d. Discuss the use, function, and appropriate application of personal protective equipment (PPE) designed to protect workers from identified electrical hazards.

e. Identify necessary training required for those employees who face a risk of electric shock.

f. For a given workplace scenario, identify the specific safety-related work practices consistent with the nature and extent of the associated electrical hazards.

g. Discuss the appropriate first aid procedures for electrical shock.

h. Identify and discuss the application and function of the major safety requirements and protective devices associated with electrical equipment and wiring in locations which are classified as hazardous.

i. For a given process, operation, or piece of equipment, identify potential electrical hazards; locate, interpret, and apply the requisite requirements and/or standards; and recommend suitable or mandated control measures.

2. Self-Study Activities (corresponding to the intent of the above competency)

Below are two web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://wastenot.inel.gov/cted/stdguido.html	DOE Standards, Guides, and Orders
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Review DOE-HDBK-1011/1-92, *DOE Fundamentals Handbook, Electrical Science*, Vol. 1 of 4.

EXERCISE 1.1-A Define Voltage, Current (Amperes), and Resistance.

EXERCISE 1.1-B Discuss the mathematical relationship of voltage, current, and resistance as applied to electrical circuitry.

EXERCISE 1.1-C Define impedance for an AC circuit.

Read DOE Order 5480.19, *Conduct of Operations,* Attachment I, Chapters VIII and IX.

EXERCISE 1.1-D Referring to DOE Order 5480.19, Attachment I, discuss the major safety concerns and appropriate control measures for working on or near electrical equipment.

EXERCISE 1.1-E Scenario: An electrician was changing fuses in a 480-volt fused disconnect. As part of procedures, he had turned a switch mechanism to the “off” position and proceeded with his work. While replacing the fuses, his right hand contacted the bottom current-carrying section of the fuse, causing an arc and knocking him unconscious. A supervisor at the scene moved the electrician away from the circuit and administered CPR.

Question: What safe work rules were violated here?

EXERCISE 1.1-F Discuss the mathematical relationship of power (P), voltage (E), and current (I).

EXERCISE 1.1-G What is the purpose(s) of grounding an electrical circuit or system?

EXERCISE 1.1-H What is the purpose(s) of grounding electrical equipment?

Read 29 CFR 1910.333, "Selection and Use of Work Practices."

EXERCISE 1.1-I Scenario: An incident occurred where a worker used an ungrounded drill while drilling a hole through a penetration seal. The worker knew there was a hidden live wire behind the penetration seal, but he believed that the wire could be avoided during the drilling operation. The bit struck the wire and an electrical current passed through the worker's left hand and went to ground through his left biceps.

Question: What violations occurred in the situation and how could they have been avoided?

Read 29 CFR 1910, Subpart I (Sections 132-137).

EXERCISE 1.1-J Who is allowed to perform repairs on electrical circuits and systems?

EXERCISE 1.1-K What institutional standards are cited for Personal Protective Equipment to protect against electrical shock?

Read 29 CFR 1910.332, "Training"

EXERCISE 1.1-L Referring to 29 CFR 1910.332, what training is required for those employees who face a risk of electric shock?

Read DOE/ID-10600, Electrical Safety Guidelines, Section 5.4.5, Electrical Equipment for Class I, II, and III Areas, and Section 5.4.6, Seals and Drains.

EXERCISE 1.1-M Why are seals required in conduit and cable systems?

EXERCISE 1.1-N Describe the purpose of a Type EZD drain seal fittings.

Read 29 CFR 1910.335, "Safeguards for Personnel Protection."

EXERCISE 1.1-O Referring to 29 CFR 1910.335, what are the alerting techniques used to warn and protect employees from electrical hazards?

3. Summary

Identification and acknowledgment of electrical hazards in the work place is the first step in developing an electrical safety program. Once identified, precautions must be put into place to prevent electric shock to the worker. Precautions include design factors for equipment or spaces, or Personal Protective Equipment that ranges from rubber gloves, insulating, mats, and blankets to the specialized tools used. All must be considered when analyzing an electrical safety program.

While the references for this study guide have been limited for ease of study, other references also apply to electrical safety. They include 29 CFR 1927, Subpart K, the National Electrical Code, ANSI/NFPA 70-1990 (NEC), and the *Occupational Safety Observer*, published by the Office of Safety and Assurance.

4. Exercise Solutions

EXERCISE 1.1-A Define Voltage, Current (Amperes), and Resistance.

ANSWER 1.1-A Voltage (E,v) is the electromotive force or pressure required to deliver energy to do the work. Current (I,a) is the component that does the work. Resistance (R) restricts or is the opposition to current flow.

EXERCISE 1.1-B Discuss the mathematical relationship of voltage, current, and resistance as applied to electrical circuitry.

ANSWER 1.1-B E=IxR, I=E/R, and R=E/I, where E=voltage, I=current, and R=resistance.

EXERCISE 1.1-C Define impedance for an AC circuit.

ANSWER 1.1-C Impedance is the opposition to a change in current or voltage in an AC circuit. It is the sum of resistance and reactance in an AC circuit.

EXERCISE 1.1-D Referring to DOE Order 5480.19, Attachment I, discuss the major safety concerns and appropriate control measures for working on or near electrical equipment.

ANSWER 1.1-D "It is imperative that equipment and systems in a DOE facility be properly controlled. Not only must the operating shift be aware of how equipment ans systems will function for operational purposes, but in order to satisfy the design bases and the operational limits, the proper component, equipment, and system configurations must be established and maintained." From: Attachment I (Chapter VIII, Discussion)

"If there is a potential for equipment damage or injury during equipment operation, servicing, maintenance, or modification activities due to inadvertent activation of equipment, a facility Lockout/Tagout program should be established and used. The Lockout/Tagout program should provide for independent verification of the removal from service and the restoration to service of safety-related and other facility equipment." From: Attachment I (Chapter IX, Introduction)

EXERCISE 1.1-E Scenario: An electrician was changing fuses in a 480-volt fused disconnect. As part of procedures, he had turned a switch mechanism to the "off" position and proceeded with his work. While replacing the fuses, his right hand contacted the bottom current-carrying section of the fuse, causing an arc and knocking him unconscious. A supervisor at the scene moved the electrician away from the circuit and administered CPR.

Question: What safe work rules were violated here?

ANSWER 1.1-E The electrician violated 20 CFR 1910.333 by not checking to see if the switching mechanism had disconnected the circuit from the voltage source. Secondly, there should have been a "safety watch" assigned and standing by the electrician performing the work not the supervisor of the area. (Source: U.S. Department of Energy, *Occupational Safety Observer*)

EXERCISE 1.1-F Discuss the mathematical relationship of power (P), voltage (E), and current (I).

ANSWER 1.1-F P=IxE, I=P/E, and E=P/I.

EXERCISE 1.1-G What is the purpose(s) of grounding an electrical circuit or system?

ANSWER 1.1-G
1. To limit excessive voltage from lighting, line surges, and crossovers with high voltage lines,
2. To keep conductor enclosures and noncurrent-carrying metal enclosures and equipment at zero potential (0 v.) to ground, and
3. To facilitate the opening of overcurrent protection devices in case of insulation failures because of faults, short circuits, etc.

EXERCISE 1.1-H What is the purpose(s) of grounding electrical equipment?

ANSWER 1.1-H
1. Limit the voltage to ground (shock voltage) on the exposed noncurrent-carrying metal parts of equipment raceways and other conductor enclosures in case of ground faults.
2. Safely conduct ground fault current at sufficient magnitude for fast operation of the circuit overload protection devices.

EXERCISE 1.1-I Scenario: An incident occurred where a worker used an ungrounded drill while drilling a hole through a penetration seal. The worker knew there was a hidden live wire behind the penetration seal, but he believed that the wire could be avoided during the drilling operation. The bit struck the wire and an electrical current passed through the worker's left hand and went to ground through his left biceps.

Question: What violations occurred in the situation and how could they have been avoided?

ANSWER 1.1-I The worker violated OSHA as well as basic, common-sense work practices. Because the position of the wire could not be confirmed, proper safeguards should have been in place for the work area.

29 CFR 1910.333, "Selection and Use of Work Practices." states that "live parts to which an employee may be exposed shall be deenergized before the employee works on or near them unless the employer can demonstrate that a greater hazard or extreme operational difficulty would result." If the circuit could not be deenergized, then safety practices described in 20 CFR 1910.333(c) should be used.

20 CFR 1910.333(c) applies to all employees who may be exposed to hazardous energized parts. Only qualified workers are allowed to work on electrical equipment or circuits that have not been deenergized. These workers must be familiar with and use the proper PPE, insulating and shielding materials, and insulated tools.

The circuit should have been deenergized with lock and tags in place. Grounded or double insulated power tools should have been utilized and insulating mats, gloves, and other protectors should have been used. (Ref: U.S. Department of Energy, *Occupational Safety Observer*)

EXERCISE 1.1-J Who is allowed to perform repairs on electrical circuits and systems?

ANSWER 1.1-J Only qualified persons (or someone in training and under the direct supervision of a qualified person) shall perform electrical repairs.

EXERCISE 1.1-K What institutional standards are cited for Personal Protective Equipment to protect against electrical shock?

ANSWER 1.1-K The standards of the American National Standards Institute (ANSI).

EXERCISE 1.1-L Referring to 29 CFR 1910.332, what training is required for those employees who face a risk of electric shock?

ANSWER 1.1-L Below is a summary of training requirements found in 29 CFR 1910.332, “Training” of Subpart S, *Electrical*:

- The training requirements apply to employees who face a risk of electric shock that is not reduced to a safe level by the electrical installation requirements of 1910.303 through 1910.308.
- Employees who face such a risk are required to be trained. The CFR targets occupations requiring training in Table S-4. Other employees who also may reasonably be expected to face a comparable risk of injury due to electric shock or other electrical hazards must also be trained.

- Qualified persons (i.e. those permitted to work on or near exposed energized parts) shall, at a minimum, be trained in and familiar with the following:
  - The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment
  - The skills and techniques necessary to determine the nominal voltage of exposed live parts
  - The clearance distances specified in 1910.333(c) and the corresponding voltages to which the qualified person will be exposed.
- The degree of training provided depends on the risk to the employee.

EXERCISE 1.1-M Why are seals required in conduit and cable systems?

ANSWER 1.1-M "...to minimize the passage of gases or vapors from one portion of the system to another portion. And ...to keep from transmitting an explosion or to keep ignition from traveling between sections of the system."

EXERCISE 1.1-N Describe the purpose of a Type EZD drain seal fittings.

ANSWER 1.1-N These fittings prevent accumulations of water above the seal.

EXERCISE 1.1-O Referring to 29 CFR 1910.335, what are the alerting techniques used to warn and protect employees from electrical hazards?

ANSWER 1.1-O "The following alerting techniques shall be used to warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts:
(1) Safety signs and tags. Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards which may endanger them, as required by 1910.145.
(2) Barricades. Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.
(3) Attendants. If signs and barricades do not provide sufficient warning and protection from electrical." From: 29 CFR 1910.335